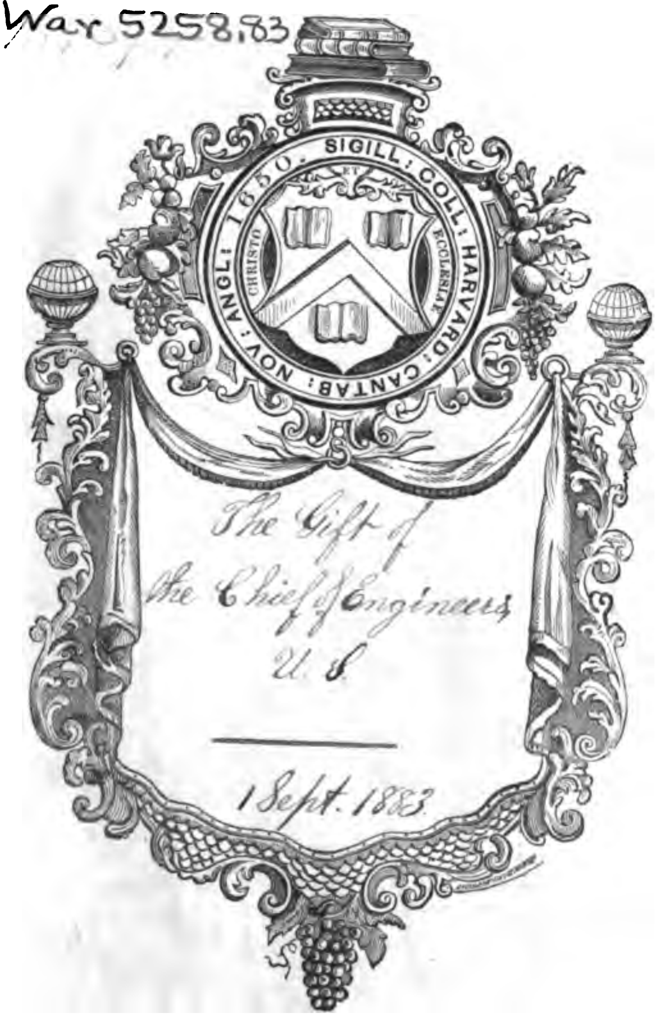
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U. S.
1 Sept. 1883

THE FORTIFICATIONS OF TO-DAY.

FIRE AGAINST MODELS

OF

COAST BATTERIES AND PARADOS.

HORIZONTAL AND CURVED FIRE

IN

DEFENSE OF COASTS.

United States — Engineer department. (1883.)

TRANSLATED UNDER THE DIRECTION OF

THE BOARD OF ENGINEERS FOR FORTIFICATIONS.

Colonel JOHN NEWTON, Corps of Engineers,

BREVET MAJOR-GENERAL, U. S. A.,

President of the Board.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
13263 1883.

1883, Sept. 1,
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LETTERS OF TRANSMITTAL.

OFFICE OF THE CHIEF OF ENGINEERS, UNITED STATES ARMY,
Washington, D. C., May 23, 1883.

SIR: The Board of Engineers for Fortifications and River and Harbor Improvements has submitted to this office translations of several articles from foreign books and magazines which it is thought will be useful to officers of the Corps of Engineers in connection with important questions of defense now occupying the attention of military men.

I beg leave to suggest that these translations, with the accompanying plate, may be printed at the Government Printing Office for the use of the Engineer Department, and that 1,000 copies be furnished on the usual requisition.

Very respectfully, your obedient servant,

H. G. WRIGHT,
Chief of Engineers, Brig. and Bvt. Maj. Gen.

Hon. ROBERT T. LINCOLN,
Secretary of War.

[First indorsement.]

Approved.
By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

WAR DEPARTMENT, *May* 26, 1883.

OFFICE OF BOARD OF ENGINEERS FOR FORTIFICATIONS AND FOR
RIVER AND HARBOR IMPROVEMENTS, &c., ARMY BUILDING,
New York, May 21, 1883.

GENERAL: The Board submit herewith articles translated from foreign books and magazines, and recommend the publication of them for the use of engineer officers.

1. Translations from "Festungen und Taktik des Festungskrieges in der Gegenwart," by A. von Bonin, General-Major, Berlin, 1878. Chapters I and II.

2. Translations from "Giornale di Artiglieria e Genio," Ottobre, 1881. "Fire against models of coast batteries and parados." Extract.

3. Translation from the same, Agosto, Settembre, 1881. "Horizontal and curved fire in the fixed defense for coasts." Extract.

It is thought these publications will be useful in directing the attention of officers to some of the important questions of defense which now occupy the attention of military men.

On behalf of the Board.

Very respectfully, your obedient servant,

JOHN NEWTON,

Colonel of Engineers, Bvt. Maj Gen'l U. S. A., President of the Board.

Brig. Gen H. G. WRIGHT,

Chief of Engineers, U. S. A., Washington, D. C.

THE FORTIFICATIONS OF TO-DAY.

[Translations from "Festungen und Taktik des Festungskrieges in der Gegenwart," by A. von Bonin, General-Major. Berlin, 187[illegible].]

CHAPTER I.

THE INFLUENCES WHICH BEAR UPON THE PRINCIPLES OF THE ART OF FORTIFICATION AND SIEGE OPERATIONS OF TO-DAY.

Although guns and small arms must always be considered of first importance in war, their influence differs in field and siege operations.

While in the field even their moral effect is no small consideration, yet this is thrown in the background when compared with their material effect in siege operations, where increased cover shields both combatants

While in field operations guns and small arms contribute only proportionately with other factors towards success, in sieges they assume a prominent and more or less decisive effect.

While in field operations the effect of small arms is of equal value with that of artillery, the latter must be considered the more important and frequently as the decisive element in siege operations.*

The extraordinary progress made during the last decades in the manufacture of arms of all kinds has exercised a great influence upon siege operations, and as a consequence upon the tactical principles of the art of fortification. The perfecting of small arms has been carried so far that against their increased range and accuracy of fire a better cover became necessary. Yet this applied equally to both combatants, without requiring a change in the system of their works.

But the latest improvements in ordnance, by the introduction of rifled guns, demanded a change in the system, inasmuch as (not considering the greater importance of artillery in siege operations) the improvement in range, accuracy of fire, and destructiveness was proportionately much greater than in small arms, especially since by the development of indirect fire, a new field of activity was opened to the artillery.

The limits of effective fire of the former smooth-bore siege guns was 600 paces for dismounting guns and demolishing embrasures, 800 paces for ricochet fire against rampart lines, and a distance of 1,500 paces generally as the greatest range for effective artillery fire; but the great accuracy of modern rifled guns admits of a range of

* Yet the relative value of artillery must not be overestimated. Of the forty-five officers of all arms killed and wounded before Strasburg in 1870–'71, twenty-two were hit by bullets; only in the artillery was the loss principally due to hostile artillery fire, but 15 per cent. of this loss being caused by musketry.

2,000 paces for counter-batteries, 3,500 paces for ricochet fire against rampart lines, while the extreme effective range of heavy guns exceeds a German mile.

The power of destruction of the new projectile is also greatly superior to that of the old spherical shot and shell; it is composed of power of penetration (square of terminal velocity multiplied by weight of projectile) and effect of bursting charge.

It may here be mentioned, for instance, relative to the power of penetration, that the projectile of the heaviest new siege gun, the 15 c. m. ring cannon, is theoretically fifty times as great as that of the old long 24-pounder.

The greater bursting effect of the new projectile, having the same bursting charge as the older spherical shells, is merely the result of the greater penetration of the former.

From the consideration of these conditions, in connection with the extraordinary increased accuracy of fire, the greater destructiveness of modern guns may be inferred, and this is heightened still more by the tougher and harder material (cast steel and chilled cast iron) now generally employed in the manufacture of modern projectiles, especially when used in a siege against inanimate and more durable objects (masonry work). Of still greater importance was the development of indirect fire of artillery, which started with the introduction of rifled guns.

Although formerly indirect artillery fire was known and employed (aside from mortar fire) in field operations with howitzers against objects hidden from view by the ground, and in sieges from ricochet and enfilade batteries, yet its effect consisted more in rendering the ground or work so fired at insecure than in obtaining certain results against a fixed object; such result could in most cases be considered merely accidental, or could only be attained by a disproportionate expenditure of ammunition.

The introduction of rifled cannon, with the extraordinary regularity of trajectory of their projectiles, led to the result that objects which were hidden from view could be reached with great certainty by indirect fire, and greatly increased the need for cover against the fire of artillery. The short 15 c. m. cannon, which is the most suitable piece of modern ordnance for indirect fire, admits, on account of its great accuracy and destructive power, a breaching of masonry when the projectile strikes with an angle of fall of 10°, and an effective side fire against gun emplacements, shelters, &c., with an angle of fall up to 20°.

Although the accuracy of its fire is reduced with greater angles of fall, it will still suffice to search by ricochet fire the terrepleins of fronts of a besieged position to the same degree as the older howitzers. Finally, it must be mentioned that the effect of vertical fire has been much increased by the introduction of heavy rifled mortars.

The long shell of the 21 c. m. mortar, weighing 160 pounds, with a bursting charge of 10 pounds, when fired at extreme range of nearly 7,000 paces, will descend from a great height, and has shown such accuracy of fire and power of destruction in the experimental firing that it seems to be destined to play a prominent part in future sieges. Yet its influence upon the art of fortification will make itself felt more in a technical than tactical point of view.

If we consider more closely the influence which the improved artillery must exercise upon attack and defense of fortified positions, we find that the long range,

combined with increased accuracy of fire, will favor the besieger so far as it will give him great freedom in selecting positions for his artillery, thereby rendering him more independent of the location of the fortified position he wishes to attack. He is not confined for his battery emplacements to a narrow area which the besieged has already prepared for that emergency, but can utilize to the fullest degree the advantages which a great extent of ground around the besieged position will generally offer him, by the existence of commanding points or by the natural cover afforded by the ground, for lines of communication and works, which require no commanding position, but must rather be hidden from the view of the besieged.

The greater distance from the fortified position at which siege batteries may now be established will give the besieger a further advantage, as it will often enable him to direct the fire of batteries intended to attack a certain portion of the fortified position also against collateral works, bearing directly upon the progress of the siege and against the interior lines of defense, without having to resort to the erection of separate batteries against each of them.

The longer range enables the defense to combat successfully the more distant siege batteries and to threaten the depots of the besieger, unless they are located at such distances from the fortified position as to render the service of the siege operations, and especially the supply of siege batteries, much more difficult.

A great extent of front development of the defense, and a formation of the ground which favors the erection of counter approaches, may greatly heighten the effects of collateral works and advanced counter-batteries against the attack. But of special importance to the defense is the great accuracy of fire of the modern guns, which will benefit the besieged in a marked degree, owing to the smallness of the target which siege works offer.

The advantages of greater destructive power of modern projectiles incline decidedly more to the side of the attack. Its works, such as batteries and trenches, built entirely of earth, and of little height, offer but small objects for destruction by projectiles, and admit a ready repair of the damages caused by the guns of the besieged, while on the other hand the raised permanent works of the defense, with their numerous masonry and bomb-proof constructions, furnish objects against which the effects of modern projectiles will be more destructive. But the service magazines and shell-rooms of the besieger, which are to be connected with the batteries, demand greater security, in view of the greater destructive power of modern projectiles.

The effects of this power, in regard to the destruction of embrasures and guns, are nearly alike to besieger and besieged.

The same applies to the needed cover against indirect fire, while in regard to the effect against covered objects the advantage again inclines towards the besieger. The narrow siege batteries and trenches are only threatened by the indirect fire of the besieged in locations where the besieger has taken advantage of the natural cover furnished by the ground, while the works of a fortified position, in their more complicated construction and with their greater depth and successive lines of defense, offer to the indirect fire of the besieger a much better field for destruction.

This is especially the case when the indirect fire is not confined to a single fixed

object, but has in view the obstruction of the fighting activity of the besieged by endangering his inner lines of communication, &c. The besieger, with works scattered over a great extent of ground, is in this case more favorably placed than the besieged, who is in part confined in contracted works of defense, where even shots which must be regarded by the besieger as misses may yet in one way or other do some execution.

Similar relations occur in regard to the greater effectiveness of rifled mortars, to whose destructive power the scattered works of the besieger offer but small objects, while to the numerous bombproofs of the besieged, crowded as they are into a narrow space, the danger is much greater and more to be feared.

But the improvements in fire-arms is not the sole cause of the changes in the tactics of sieges and the art of fortification; other influences have been largely at work, among which may be mentioned the latest developments in the social and political condition of European states and the increase of lines of communication, especially of railroads.

Since in nearly all of the important military states compulsory service in the army has been introduced, and the present conditions of commerce and international ties have produced a greater dependence upon one another, each war strikes so deep at the root of national life and the welfare of the whole people that a war of several years' duration becomes almost an impossibility. Therefore each war's result must be achieved in the shortest possible space of time, and the former slowness of action must be replaced as much as admissible by greater energy and a display of personal and material forces which in former times was unknown and unattainable.

In siege operations of to-day the greatest possible supply of guns and ammunition must be provided, and especially a lasting supply of the latter must be insured. To this end railroads have become an almost indispensable auxiliary, and the great facility of this means of transportation has considerably abridged the former limitations in regard to weight of guns and projectiles.

Transportation which was formerly looked upon as impossible has become, as a consequence, practicable in the siege operations of to-day, especially of gun ammunition, which for some calibers has been more than doubled in weight.

Economy in the expenditure of ammunition, which naturally interferes with attaining quick successes, can now be abandoned, and, as a matter of fact, the siege operations of more recent years have shown an expenditure in this line which would have surprised our forefathers.*

These great transportation facilities by rail can be utilized by the besieged only so long as the lines are not cut by the enemy. To the besieger, as a rule, they will remain of permanent benefit, as his connection with the outside and his depots remain open.

It may be concluded from all these considerations that the influences which have recently affected siege operations will, as a rule, be of greater advantage to the besieger than the besieged, and that the equilibrium between the two, the establishment of which was repeatedly attempted after the appearance of Vauban's system of attack, and was

* The artillery before Strasburg in 1870 fired 200,000 rounds, a total weight in metal of 8,200,000 pounds, while formerly the estimate for an especially large siege, of long duration, was 2,000,000 pounds.

successfully attained by the "new Prussian method" of fortification, has been again destroyed. Under these circumstances a radical modification of the art of fortification, that is the material foundation of the defense, became unavoidable, and brought with it corresponding changes in the maxims of successful defense as well as of attack.

CHAPTER II.

THE FORTIFICATIONS OF TO-DAY.

It was mentioned in the introduction that by degrees the earlier views of the object of a fortress developed into a more correct estimate of its aim in connection with the operation of armies in the field, which assumed a definite scientific form after the war with France in 1813–'15 (*Freiheitskrieg*). Time and the experience gained from the great wars which have since occurred have confirmed this estimate. Analyzing closely the task imposed upon the fortress of to-day, we shall find that it divides itself into a strategical and a tactical one.

Large places of arms are to-day required to furnish points of support for the defense of a country, and are called into existence by the necessity of fortifying either some political central point or the more important manufacturing and mercantile cities of a threatened district. These positions require large and active garrisons in order to extend their influence over the whole section of the country so threatened.*

In a defensive war these fortified positions must serve as points of support for the army in the field (which latter would operate only in a strategically defensive manner, requiring the utmost freedom of action), and also as reserve depots for all needed supplies. It therefore becomes necessary that these fortified positions shall be able to withstand effectually, without the aid of the army in the field and with a minimum strength of garrison, the attack of a superior enemy; furthermore, they must serve the army in the field as a temporary resting and recruiting place. For this reason room is required which a fortified town seldom offers without the addition of an armed camp or the belt formed by a line of detached forts.

The extensive use of detached forts in order to force the enemy to a distant and more difficult attack was no innovation, but their importance was increased by the fact that in a modern place of arms the aim to be reached was the security of a large amount of national property and wealth which, by the increase in the destructive power of artillery, had become endangered in a much higher degree and at much greater distances than formerly.

While it was deemed sufficient in former times to have forts placed a few hundred paces from the fortress, and at points only which would most likely form the front of attack, it now becomes necessary to protect the fortified town, the heart, as it were, of the whole position, on all sides, at such a distance that its safety would be in no wise imperiled by an attack on the forts. Hence an inclosed zone must be formed around

* In his memoir of 1816, already referred to, General von Grolman rightly pointed out that the strong garrisons required for a few large fortified positions would take from the army in the field a less numerical force than would be garrisons of the numerous small fortresses of former times.

the fortified town by a belt of detached forts, broken only where impassable ground at a great distance obviates its necessity. The distance of the forts from the enceinte of the fortress must be from 5,000 to 6,000 meters, corresponding to the range of modern ordnance. This naturally gives an extraordinary length to the fort belt, which thus loses the effective support of the interior enceinte and has its character entirely changed, since this support was formerly one of its main features of strength.

The long range of modern guns permits placing forts at greater distances from each other than formerly, as 3,000 to 4,000 meters in an open country can be effectively defended in daytime, but where the ground is broken and against night attacks smaller works between the forts are resorted to, which also serve as points of support (that cannot be taken by storm) for the pickets and the whole exterior line of defense.

The severing of the fort belt from direct tactical connection with the enceinte necessitated a construction and armament which should make them independent. This was obtained by greatly increasing their size.

Furthermore, the fort belt in itself was now regarded as the principal and strongest line of defense. This compelled the surrender of the fundamental maxim of the "New Prussian School of Fortification," viz, augmenting the material strength toward the interior. The increasing importance of the fort belt has even led to the inverting of this maxim so as to lay less stress on the material strength of the interior lines of defense (the enceinte) and to increase that of the forts. Further on, in the chapter on "Tactics of the defense of a fortress," it will be stated that this principle is justified in the light of the present state of active defense, but yet must not be carried so far as to surround a place whose subsequent defense is necessary with a simple wall safe against assault. Such a view would be synonymous with the supposition that a penetration of the fort belt compels the abandonment of all further resistance. On the contrary, the enceinte must be in such a defensible condition that a break through the fort belt would still compel the enemy to resort to a second regular siege.

This active defense, as well as the fundamental idea that such large fortified positions will furnish at times points of support for the army in the field to rest upon, and will also facilitate at the proper time the resumption of active operations of the latter, requires the fort belt to take in general the character of an offensive position in order to enable the troops, if necessary, to debouch quickly *en masse.*

These conditions, as well as the necessary armament and defense of the fort belt, demand good communications. Therefore a belt road of easy grade will run in rear of the fort belt, protected as much as possible by the natural ground, and if public roads do not furnish the required communications, other roads, radiating from the belt road to the fortress and the principal depots and magazines, will have to be built.

Along the fronts most likely to be chosen for an attack by the enemy, and where the ground admits, or where railroad lines already exist, the belt road might be replaced by a railroad.

Such large fortified positions* satisfy, besides their strategic object, almost always tactical requirements, inasmuch as they generally surround the junction points of main

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*The annexed drawing, illustrating the siege operations against a fortress and the manner of its defense, gives a the same time a sketch of a large modern fortress, which will assist the non-professional reader to form a general idea of the extent of the requirements needed for such a place.

highways and railroads, and are usually situated on large rivers, thus insuring a safe crossing from one bank to the other. But their small number is inadequate for the present mode of rapid warfare, which, especially in strategical defensive operations, has often to be substituted for the needed but lacking forces; therefore these fortified positions will have to be supplemented, according to the nature of the theater of war, by fortifications having chiefly tactical objects.

The successful defense of important districts which are formed by rivers, lakes, chains of swamps, mountain chains difficult of access, &c., require their passes to be fortified.

The extension of railways throughout the greater part of Europe and the great importance which such lines of communication have acquired in recent warfare make other works necessary, besides the larger fortified places, in order to prevent the enemy from using important lines of railways, and also to secure prominent defiles and works of engineering art for our own use or to defend them against hostile destruction. For this reason local works become necessary whose extent is solely defined by tactical consideration.

If we should classify the fortresses of to-day, by their military importance, into strategical and tactical ones, such a division would have only a theoretical significance. Individual fortresses can seldom be so classified; the general character of the war will decide whether a large fortified place will not for a time have to serve solely tactical objects, or, in like manner, whether a small tactical position may not become of strategical importance. Each country can show fortresses which at first could not be placed in one category or the other, and which may well be termed "fortresses of occasion."

Although many of the smaller forts, creations of former centuries, have been entirely abandoned during the last decades, in most countries, when their military importance was disproportionate to the cost of their maintenance and the expense of a garrison and armament in time of war, yet many of that class are still retained, at least temporarily. This action is undoubtedly justified by the fact that many old fortresses, although not situated in the most advantageous positions, may yet at times assume a certain importance, and that it would be wiser to preserve them, provided their maintenance and defense does not require disproportionate sacrifices, than to abandon them and be compelled to replace them in a little more favorable location by new fortresses perhaps at great expense. The smaller importance attached to these older retained fortresses, designated above as "fortresses of occasion," is seen by the decisions as to their garrisons and armaments.

Of still greater importance than the general conception just given of the object of a fortress of to-day is the special construction of its parts. In view of the state of modern ordnance it became necessary to cover garrison and armament in a much greater degree than formerly, without impairing their efficiency, and to withdraw more important destructible objects from hostile fire.

The data given in the preceding chapter as to the effectiveness of modern guns furnished a basis for determining the extent of those requirements. This involved a radical change of the former principles of construction.

This necessity of increased cover applies to the fortresses as well as to their garrisons and armaments. In the fortress it affects construction in masonry, wood, and earthworks which are easily destroyed, such as embrasures, bonnets, &c.; but the means employed for satisfying this demand must not interfere with the first principle of a permanent fortification, namely, absolute safety against assault. Hence all masonry and wood used in the construction of new fortifications are so arranged that they cannot be reached even by indirect fire. The scarp-wall, which insures safety against assault, is as much as possible covered from fire by its smaller height, the greater depth, and lesser width of the ditch. The reduced height of the scarp-wall increases the importance of an effective flanking defense. Formerly in ditches with salient angles this defense was obtained by caponnières situated in the re-entering angles, in which case they are exposed to the indirect fire of the enemy. To obviate this they are now generally placed in the salients.

The fire towards the exterior from guns in casemated batteries had to be entirely abandoned. The usual stone or wooden bomb-proof shelters for guns became inapplicable on account of the great accuracy and destructiveness of modern siege artillery. It also became necessary to give up the fire of the howitzers from the upper casemates of the keep, which defended the foreground, as such use of the keep was inconsistent with their own security against indirect fire. This latter circumstance also caused in most cases the inner defense of a work from a casemated keep to be abandoned as the keep in order to fulfill this requirement could not be protected against fire having an angle of fall of 10 degrees. It was naturally with great reluctance that these valued casemated keeps were renounced,* and not until other means had been tried to make them less vulnerable, such as the armor plating used for vessels. But the results of these trials were not satisfactory, and it was therefore determined to use casemated defensive works in positions only where they would be protected against indirect fire by local surroundings. The subject of iron plating for special cases, principally for sea-coast defenses, will be treated separately in the appendix.

As these defensive casemates became impracticable, so also were the block-houses in the covered way rendered useless, much as they were formerly valued. The covered way thus lost its importance as a line of defense, and its original object, that of a sheltered line of communication for outside guard duty and as the base line for sorties, came again prominently to the front. This change and the necessary abandonment of a casemated keep in the interior necessitated a surrender, in the special construction of works, of the former maxim, increasing strength toward the interior. The importance of the rampart as the principal line of defense became more and more pronounced, and with it came the demand for greater security in its defense. For this purpose the gun platforms and the lines of communication along the terterreplein were lowered; barbette guns intended to repel assaults were provided with carriages of increased height; those guns intended for service in the regular siege

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*Neither France nor Austria has entirely abandoned the keeps in the interior of works. Austria employs open earthworks secured against assault by revetted ditches, while France uses casemates whose scarp-walls are protected by earth embankments provided with "Haxo" embrasures. Our artillery would look upon this expedient as insufficient.

The solution of the problem of an effective and sufficiently protected keep for new works may be regarded by the engineer officer as a question of the future.

were to rely mainly upon indirect fire, as the accuracy of modern ordnance prohibits the deep embrasures formerly used.* To guard against enfilade the number of traverses was increased. On lines exposed to richochet fire one gun was placed between two traverses, and on other lines no more than two guns were mounted between two traverses. Ammunition required for immediate use was placed under the breast-height wall or in traverse magazines. The bomb-proof shelters in these traverses having sufficient earth cover toward the enemy may be used during temporary overwhelming hostile fire to cover the gunners and the lighter guns which serve to repel assaults.

The former principle of providing the troops not directly engaged in the defense with bomb-proof quarters remained in full force, and its application was given even a wider field. Of the garrison the artillerists are the principal actors in the defense, while the infantry appears only as pickets during the first stages of the siege, and later on as sharpshooters behind the breastworks, when the rules for protection of the artillery apply to them The employment of large masses of infantry behind ramparts occurs, and that temporarily only, when it becomes necessary to repel an assault. The same means, such as the lowering of platforms and erection of bomb-proof traverses, which were cited as means of protection for the armament, will also shelter the troops actively engaged in the works or held in readiness in the immediate vicinity. This security may be further enhanced by the erection, in suitable places, of light splinter-proofs, formed of gabions, to protect the troops against pieces of shell, which latter projectile is now almost exclusively used in artillery combat. The bomb-proof casemated keeps, formerly used for the safe quartering of the remainder of the garrison, being now abandoned, it becomes necessary to provide other quarters in reverse casemates under the rampart.

In detached works with closed gorges, casemates for quarters may be arranged in the sides of the gorge which are not exposed to hostile fire, protecting them toward the enemy by earth cover. The same care must be taken in the storage of all supplies needed for the garrison. Rooms in basements not suitable for dwelling purposes will furnish a place for storing provisions. Airy and dry casemates must be especially provided for the ammunition and its preparation. The complicated ammunition of the heavy rifled guns cannot be stored in large quantities ready for immediate use, and the final combination of the different parts, viz, empty shell, powder, and fuze, usually takes place but a short time before they are needed. Besides the powder magazines and shell stores, separate loading rooms are required, which may be arranged below the terreplein, and when connected by lifts with the hollow traverses above will land the finished ammunition, well protected against hostile fire, close to the guns.

Finally, greater attention must be paid to the protection of the communications inside the works on account of the increased effectiveness of the siege guns. This is in part obtained by the increased number of traverses on the terreplein, but in far advanced positions in danger of being surrounded, and especially in detached works, large traverses in the direction of the capital and middle traverses (parados) are indispensable. They subdivide the interior of the work, furnish protection against indirect

* The experience of siege operations in 1870 have again shown the facility with which deep parapet embrasures, universally employed by the French, can be destroyed.

reverse fire, and admit of bomb-proof communications between the gorge and the casemates under the rampart. In very much exposed works it will be even necessary to have such bomb-proof passages extend along under the whole rampart, connected by stairs with the traverse bomb-proofs on the terreplein, in order to be able to dispense entirely with the open parade and ramps as lines of communication during a heavy and concentrated hostile fire.*

It is to-day the duty of the engineer officer to satisfy as much as possible these conditions in all works of defense; and although difficulties may present themselves in older fortresses, the new fortifications will admit of an easy solution of this problem. Yet these requirements and the ways to meet them are not entirely free from discussion; on the contrary many different opinions are held by the various branches of the service. The science of fortification is by no means immutable, but subject to development and improvement. The creations of the engineer officers of to-day will embody maxims in accordance with the present state of the art, which will furnish the foundation for future development. It will now be briefly stated how the engineer officer arranges the different main features of a modern fortress in order to meet the above-mentioned requirements.

For the detached forts in the fort-belt of a large fortress the well-tried form of the lunette is usually employed, its salient angle is assumed as large as possible (130° to 145°), partly to withdraw the faces from hostile fire and partly to increase their front fire, which is intended to combat effectively the first appearance of siege batteries. The direction of the flanks is governed by the adjoining works, but will deviate little from a line parallel to the capital. The gorge of the forts must be closed by a defensive rampart on account of the great distance from the enceinte in the rear, and its trace may either be bastioned or a slightly broken line.

The size of a fort depends upon its importance relative to the rest of the whole fortified position. The faces will commonly measure from 75 to 125 meters, the flanks from 50 to 75 meters; thus the fort will acquire dimensions greatly in excess of older similar works, being in accordance with the increased importance demanded at the present day.

The covered way of a detached fort does not serve mainly as a base for offensive operations which can better be carried on from the flanks of the fort, but will be principally used for outside picket duty up to the last stages of the defense. It will therefore be sufficient to make it a simple *chemin des rondes*, which at the gorge gives a communication to the wing-glacis (*Anschluss-glacis*) and is widened at the entrance to the gorge into a place of arms provided with a tambour and block-house in order to secure the communications. (Observe the object of the wing-glacis further on.) By means of this disposition of the covered way and by the greatest possible reduction in the width of the ditch it becomes practicable to protect the masonry of a scarp, not more than 5 meters high for faces and flanks, against the indirect fire of the enemy; but as such a height would not afford satisfactory security against assault and as the location of the forts, usually on commanding ground, seldom permits the use of wet

* It seems to be a fundamental principle in France to employ such continuous bomb-proof passages under the rampart.

ditches, it becomes necessary in order to obtain this security to employ other means, such as a good flank defense of the ditch and a high revetted counter-scarp provided with mine chambers. In the scarp of the gorge, which is not exposed to the fire of siege batteries, bomb-proofs may be located and the scarp wall made correspondingly higher.

The usual double caponnières at the shoulders of the lunette for flanking ditches can no longer be employed, as the hostile indirect fire in the direction of the faces would readily demolish them. They are usually replaced by a caponnière at the salient arranged for artillery to sweep the ditches along the faces and by two single caponnières at the shoulders in the prolongation of the faces for musketry defense of the shorter flanks. If the gorge be constructed on the bastioned system, the ditch defense will be obtained from the casemated flanks; if it is a single broken line, it will require a ditch caponnière. All caponnières are reached from the interior of the fort by posterns.

The reasons which formerly induced the employment of an expensive scarp wall, in order to bring the fire of the infantry as near as possible to the crest of the glacis, have, on account of the improved arm, no longer any weight, and the scarp of the rampart along the faces and flanks is, for economical reasons, formed by earth slopes guarded against assault by a detached wall at their foot of smaller dimensions

The surrounding country will control the height of the rampart, which should have the fullest command over the exterior ground. This height will seldom be less than 8 or 9 meters. The greater effectiveness of modern siege guns demands that the thickness of the parapet be increased to about 7 meters. The gorge wall requires a less commanding height; it is sufficient when it furnishes a protection to the faces and flanks against the reverse fire of a hostile assault; the thickness of its parapet, which will not be exposed to the direct fire of heavy siege guns, may be reduced to 4 meters.

The parapet of the faces and flanks will at the outset be arranged for gun emplacements, that of the gorge for musketry defense, which may at a later stage have to give room to guns; its terreplein, therefore, must have at the beginning the necessary width for them. The erection of traverses and especially the building of a parados will be determined by the conditions already stated. This applies also to the arrangement of the interior, and above all to the amount of bomb-proof shelter.

The quarters for the garrison will in most cases be found in the extensive casemates of the gorge, which must also furnish accommodations for a hospital, and their basements, kitchens, store-rooms, &c. Reverse casemates provided with a sufficient number of exits for guard details and troops under arms are to be constructed under the terreplein of the faces, to which may be added, in case of need, the cover furnished by the posterns, or they may be entirely replaced by the latter. The room furnished by the posterns will be sufficient to admit of the safe storing of a part of the war material not required for immediate use.

The bomb-proof shelters in the traverses will furnish temporary cover for troops engaged on the terreplein.

Each fort will need at least one large storage magazine, built entirely in the body of the rampart, thoroughly protected against hostile fire; also, according to the size of

the fort, two or three shell-loading rooms, each provided with a powder magazine and the necessary room for storing the different parts of the gun ammunition.

In the chapter on the defense of a fortress it will be more fully stated that the continued artillery defense against a regular siege is not actually the duty of detached forts, but of batteries especially constructed for that purpose, and that the heavy guns of the fort will be placed in low-lying batteries at the flanks of the fort in the so-called wing-glacis. These low batteries, the dimensions of which are governed by the fixed armament of the corresponding fort, and which are located at the gorge angles of the fort glacis, are frequently constructed in time of peace. The considerations of their own cover will guide in a great measure the arrangement of their profiles. No more than two siege guns are placed between hollow traverses, and light guns are stationed at their extreme ends to repel hostile assaults.

The infantry support of these batteries forms the reserve of the outside pickets after the troops have been forced back by the enemy from advanced positions in the outlying country (see Chapters III and IV). They as well as the gunners will find temporary cover in the hollow traverses against a sudden overwhelming fire of the enemy.

These batteries depend upon the forts to which they belong for ammunition and supplies, but for immediate requirements small storage places are arranged in the slope of the breast height.

As already mentioned, the intermediate works erected between the forts where circumstances demand their construction will mainly serve as points of support in the defense against assaults; they are not intended to participate in the actual artillery defense. They must be made perfectly secure against assault, must therefore command the surrounding ground and have the required bomb-proof shelter for their garrison.

A small lunette or redoubt with three or four field pieces and a garrison of fifty to sixty infantry will fulfill these conditions. On account of the small size of the work the *chemin des rondes* along the counter-scarp will be dispensed with, the narrow ditch will be generally dry owing to the elevated location of most of these works, and their security against assault will be obtained by the high revetment of the counter-scarp, a detached wall at the foot of the scarp slope and caponnières arranged for musketry for the flank defense of the ditches

The gorge wall contains a set of bomb-proof casemates covered with earth toward the enemy, which furnish quarters for the garrison and store-rooms. A shell-loading room and magazines must not be omitted; in fact, all the arrangements will be similar to those of the detached forts, only on a smaller scale.

In regard to the construction of the inner enceinte it has already been remarked that to-day a less material power of resistance is given it than formerly on account of the security furnished by the strong surrounding fort-belt. Its main requirements are security against assault and favorable positions for gun emplacements, and with it disappears the necessity of forming a deep line of defensive works The enceinte is usually formed by a simple polygon trace, with sides about 800 meters long (double the distance of grape-shot range); the salients are placed on commanding ground, and

in them as well as in the middle of long lines are erected the more prominent works of defense, of strong profile connected with each other by low intrenchments. The various flanks are flanked by center caponnières arranged for artillery defense, which will be sufficiently protected in dry ditches against indirect hostile fire, but in wet ditches which require, when of small depth, a greater width in order to furnish the necessary amount of earth for the embankments, the caponnières will generally be protected by an earthen envelope.

We recognize in the general arrangement of the enceinte the principles which governed the construction of the fort-belt; the more prominent works in the enceinte correspond to the forts and their intermediate works, the line of intrenchments to the wing-glacis and those intermediate batteries which are thrown up at the opening of the siege. Nevertheless the nature of the enceinte requires many modifications in details.

First, the enceinte cannot dispense with a spacious covered way provided with places of arms, as it must not only serve as a base for outside picket duty, but also as a place of rendezvous and a starting point for sorties.

The arrangement of the main ditch will depend upon whether the ditch is to be dry or can be flooded. In the first case the counter-scarp as in forts will have a revetment, and a loop-holed wall will be placed at the foot of the scarp; in the second case a wall at the foot of the scarp will suffice; in either case means, such as defensible ramps or bridges, must be provided to admit of the crossing of the ditch by troops in case of sorties The main works of the enceinte are arranged like the forts, but they may be of a less independent character on account of their direct connection with the intrenchments and the town. If we go so far as to make them works with open gorges, merely commanding the intrenched lines, thereby renouncing success in independent lines along the front (*frontale Gliederung*), which was the principle of the former Prussian method of fortification, the difficulty of an energetic defense of a fortress after the enceinte has in one place been broken will be greatly increased. It will be self-evident that the slight increase of cost which will be incurred in giving these main works a tactical independence by disconnecting them with the intrenched lines and closing their gorges, judiciously limiting the necessary work, will not be misspent on fronts which would probably be chosen by the enemy for an attack.

The higher ramparts and terrepleins of these main works serve as principal traverses for all the fronts of the enceinte, and offer at the same time a location for the erection of those bomb-proof shelters which are necessary for secure quartering of the garrison and their supplies and which seldom could be found in low lines of intrenchments. This applies mainly to the cover needed for guards and such troops as are held in immediate readiness, to store-rooms for ammunition, and shell-loading rooms, while for the troops off duty, for storing of the main supplies, and for large storage magazines, other safe localities will be found in a large fortress.

The necessity for protection against indirect fire exists here in a less degree than in detached forts. The latter have to expect a concentrated fire in a narrow confined space where shots which miss their mark are seldom lost, while from the great length of the front and the small depth of the enceinte an individual point is less endangered. The number of traverses and bomb-proofs may therefore be reduced.

A good military road behind and along the whole enceinte, provided with ramps leading to the terreplein, must give the necessary means of communication, but for sorties and for communicating with the outside pickets the gates which are used for open traffic in time of peace will not suffice, and posterns connecting with the ramps or bridges across the ditches must be added.

The general conception which forms the basis of the principles laid down for a large fortress, and especially the arrangement of the closed enceinte, will naturally be subject to many modifications in its practical application. The general plan of the town to be fortified, existing prominent water-courses and railroads, the form and character of the surrounding country, the extent of resistance which the different parts of the whole line of defense will need under these conditions, and other considerations, will always influence the construction of the enceinte, and will exclude the close application of a fixed system even to a greater degree than in the former Prussian method of fortification. The ground must determine the proper form of construction for each fortification, and rulers and dividers will only find their use within the limits just given.

This last maxim applies in a still higher degree to small fortresses of mainly tactical importance. They will appear in manifold shapes, from the small keep on a railroad line, near the greater works of engineering art, or in a mountain pass, to the fortified town of medium size, which perhaps guards the meeting-point of highways, and, if situated on a large river, their crossing. Still, the value of such a tactical fortress is not so varied as that of a large fortified position, and, therefore, great extent of line is to be avoided, as it would entail large expenditures of money for construction and repairs, and in time of war make large demands for its necessary armament and garrison. Nevertheless, it will be necessary that these fortresses, as long as they are not merely keeps for defensive purposes, should permit large bodies of troops to assume offensive operations against the enemy; hence, as a rule, they must have a number of detached forts, located at the most favorable points in the surrounding country, under whose protection the troops can organize for offensive operations.

These detached forts of a small fortress give a certain protection to the heart of the whole position, the fortified town, against an immediate hostile bombardment, but rarely to a sufficient extent, as they do not surround the fortress on all sides, and are usually placed much nearer than those mentioned above, which encircle large fortified positions. These small fortresses can, therefore, very frequently be completely surrounded and bombarded from all sides; the limited space within will furnish no place where the garrison and war material would be protected by location alone, and hence to a greater extent special bomb-proof shelters of all kinds must be provided.

This is usually looked to in the construction of new tactical works of small size, but in old fortresses, which are mainly retained for tactical reasons, as especially in those which were designated as "fortresses of occasion," the great expense of the numerous new bomb-proof shelters is an objection, the more so as the room for them is lacking in the usually crowded fortified towns, and the value of such a fortress is usually but a relative one. The want in this direction is left to be supplied on the appearance of danger of war, when the usual preparations for armament take place.

But with such old fortresses the examination of the construction of their works with reference to their fitness for modern guns and their material power of resistance against the fire of these guns becomes a matter of absolute necessity. The works must be modified to admit of the employment of the former, and against the latter their weaker points will have to be protected. Such protection may assume great and objectionable dimensions, as for instance when the revetments are too much exposed, or when there are numerous defensive casemates and other works of masonry which are insufficiently protected against indirect fire. Revetments can only be protected by raising the glacis, which entails a change in the whole profile system of the works; insufficiently protected casemates will require earth covers, whereby their usefulness may be impaired, and their defensibility will always be questionable. The engineer officer is here confronted with a problem, whose solution cannot be evaded, which often requires more judgment than the planning of a new fortress, since one cannot undertake the indiscriminate destruction of the old, and the creation, with unlimited means, of the new, but must modify the old to suit the requirements of to-day, with the most limited expenditure of money.

To what extent this remodeling of a retained older fortress may be carried on depends upon its general military importance, the possibility of its usefulness in time of war, and upon the length of time which it is desired to preserve it. In this connection it must be borne in mind that the length of a siege will depend in a certain measure upon the material strength of the works; but the effectual defense of a fortress will rest on the judgment and energy of its defense, provided the necessary strength in troops and armament is not lacking.

FIRE AGAINST MODELS OF COAST BATTERIES AND PARADOS.

[Translation from Giornale Artiglieria e Genio, Ottobre, 1881.—Extract.]

DEDUCTIONS DRAWN FROM EXPERIMENTS.

From the results of the experiments, and especially from those obtained in the last series of comparative tests, which may well be considered the best on account of the number and variety of the projectiles and the better conditions under which they were made, we may derive the following conclusions:

I. It was proved that parados exposed to the fire of field artillery, whether of sand or, still better, of earth, are entirely without danger. Indeed, they are usually of value, since, besides covering the battery from reverse views and reverse fire, they act as cover against splinters, and by limiting the radius of dispersion of splinters, defend in some degree against shells that the enemy bursts at the level of the ground beyond the parados, and against projectiles which, falling in its place, if the ground was unincumbered, will now be buried in the parados.

II. Against a fire of siege artillery the really dangerous zone—that in which the projection backward of splinters or of earth or sand is great—does not extend beyond 15 meters, so that we may say a parados 20 meters from the gun platform will do no injury. This limit may be somewhat reduced for batteries much higher than the attacking guns, on account of the reduction of danger due to smaller probability of being hit. If no calibers exceeding 12 or 15 c. m. are to be feared, this distance may be reduced to 15 meters.

III. In works like sea-coast batteries exposed to the fire of heavy artillery, parados at only 20 or 25 meters from the gun platform would be more dangerous than useful. Even if no splinters were thrown backward, the extraordinary quantity of sand or of earth that within that limit would be thrown backward by the striking and bursting of large projectiles, would render the service of the batteries very unpleasant and in many cases impossible, and would prevent the maneuver of the obturators of the gun should the breech be opened at the moment a shell struck the parados.

Removing the parados to 30 meters from the gun platform, we may consider the battery nearly secured from the effect of large projectiles like those of our 24 and 32 c. m. guns. It is true that some splinters may be thrown backward into the battery, but the danger from some rare splinters should not lead us to renounce the advantages which may result in some cases from parados.

To estimate the small importance of such a danger it is well to notice that out of a total of twenty shots fired from 24 and 32 c. m. rifles and the 22 c. m howitzer, the target, representing a battery formed by a continuous screen 9 meters high and 15 meters from the parados, was struck by only six splinters. At twice the distance we may assume it would have been struck by still fewer. It may be further noticed that in the experiments, the fire being at short range, the angles of fall were much less than will occur in war, in which the projectiles, being fired from greater distances, would strike the parados with a greater angle of fall, would penetrate more and have a less tendency to rise, so that the projections of splinters, earth, and sand would probably be less than in the experiments.

We may, then, admit as satisfactory this limit of 30 meters distance for parados that may be battered by guns of heavy caliber, and this limit, like that mentioned before, for batteries exposed to the fire of siege artillery, may be somewhat diminished when the battery stands at a distance high above the assailant.

In any case, however, the parados, to be free from danger, should be formed of selected material free from stones.

IV. Admitting these limits of distance, it is necessary to give to the parados considerable dimensions and also to increase the depth of the work in a way not always consistent with the narrowness of the site. But such difficult requirements, as also the greater and almost doubled thickness of the parapet, are imposed on us henceforth by the increased power of modern artillery, and we cannot avoid them in the choice of positions and study of the *tracé* of the works without renouncing sites which give the best action for artillery.

Parados have, without doubt, their inconveniences, but when it is not possible to withdraw the battery from the command of dangerous heights in rear, when there is inevitably some face or flank of the work exposed to reverse fire, when, finally, it is not possible to avoid, at short distance in rear, masonry works or rocky earth, it is certainly best, of two evils to choose the less.

V. For parados in general, and especially for those exposed to the fire of heavy artillery, earth may be considered better than sand when it has been cleaned from gravel and stones.

Indeed, comparing the effects of fire into sand and earth with the larger calibers of 22, 24, and 32 c. m., and especially with the bursting shell of 22 c. m., it is seen that with a parados of earth the backward projection of splinters is nearly always less dangerous as to number and as to distance, resulting, as has already been seen, from the greater penetration of the projectiles into the earth, which thus opposes more resistance to the projection of splinters. It seems, moreover, aside from the greater or less penetration of projectiles into earth, that it, by its nature, has the property of holding or, so to say, swallowing the splinters, the singular fact presenting itself that in a second series of experiments at Ciriè, in ten shots made with the 22 c. m. howitzer, half with the bursting shell and half with the light shell, there were in all twenty-five splinters thrown out from the parados, none of which went beyond the first row of targets, at only 15 meters distance. There is also the fact that in the last comparative

experiments the parados of sand always sent backwards more splinters and to a greater distance, and this, too, when the shells burst after stopping.

As to the projection of sand or earth alone, the dangerous zone has nearly equal width for both parados, and only a few clogs of earth fell beyond it. But with the earth there was not that suffocating dust which was produced by the sand, rendering the air irrespirable for many moments, and which filtering into the closing joints of the breech-loaders, prevented their working.

VI. Finally, it does not seem that a fuze with a retarded burning increased the damage of the bursting projectiles in the parados, but rather, as was observed in the experiments made at Via reggio by the Royal Navy, the projectiles furnished with ordinary percussion fuzes were more dangerous.

CONCLUSIONS.

Combining the observations made, we may conclude:

I In temporary batteries, and also in those permanent ones which can only be attacked by field or siege artillery, parados, even at short distances, are not only free from danger, but also in most cases are advantageous.

II When in works subjected to fire of greater calibers parados have to be used, well-sifted earth should be chosen in preference to sand in their construction.

Their distance from the battery, measured from the foot of the interior slope of the parados to the end of the gun platform, should not be less than—

Twenty meters if the work is exposed to the fire of siege artillery of calibers not greater than 15 c. m., nor less than—

Thirty meters if the work is exposed to more powerful artillery.

These limits may be somewhat reduced for batteries high above the position of the attacking artillery.

III. As the inconveniences resulting from parados placed at distances less than those indicated may in many cases be less than that proceeding from the fire of musketry or of artillery placed in commanding positions in rear of the battery, so in especial cases in which fortifications have to be constructed the importance of the two dangers will have to be compared, in order to judge whether it is better to place parados at less distances or to expose the battery to reverse fire.

HORIZONTAL AND CURVED FIRE IN THE FIXED DEFENSE FOR COASTS.

By Captain P. BARABINO, *Italian Artillery.*

[Translation from Giornale di Artiglieria e Genio, Agosto-Settembre, 1881.—Extract.]

But it may be objected that the probability of hitting by curved fire is small, and that sea-coast artillery will waste many shots in firing with full charges at great distances, or with reduced charges at large angles at smaller distances. It is impossible not to recognize, up to a certain point, the truth of the objections; but a sufficient answer is that in war economical considerations lose value, and that hitting an enemy's vessel with curved fire is not so difficult that we should consider such fire simply a waste of ammunition.

Suppose now the vessel at rest, either with its keel in the plane of fire or normal to that plane. And suppose the vessel of the dimensions given in Chap. IV, namely, 100 meters long and 18 meters broad, and suppose the horizontal target represented by its deck to have those dimensions. Suppose also our gun to be the 24 c. m. cast-iron breech-loading rifle.

For direct fire at 9,000 meters the rectangle containing 50 per cent. of the shots is 11.2 meters broad and 85 meters long. At 6,000 meters it is 5.5 meters broad and 70 meters long. With the same gun firing at 5,000 meters, with a charge of 18 kilograms and an elevation of 22°.6, the rectangle will be 33 meters wide and 115 meters long; and with a charge of 20 kilograms and 21°.4 elevation, firing at 3,350 meters, the rectangle was reduced to 1.29 meters by 43.58 meters. From these data we have the following probabilities of striking with curved fire the vessel under consideration:

DISTANCE OF THE VESSEL, IN METERS.

	9,000.	6,000.	5,000.	3,350.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Vessel with keel normal to the plane of fire...	11.5	13.5	18	22
Vessel with keel in the plane of fire..........	41	64	74	87.5

The 28 c. m. Krupp howitzer, in the experiments of March, 1879, firing with an elevation of 45° at 7,800 meters distance, had 50 per cent. of its shots contained in a rectangle of 7 meters by 54.28 meters; firing under angles of 28° 36 at 6,800 meters the rectangle is 2.6 meters by 44.7 meters; and firing under the angle of 30° at 3,550

meters the rectangle was 2.37 meters by 28 meters. Hence the supposed vessel would probably be struck at the several distances by the number of projectiles given in the following table:

Distance in meters.	Vessel with keel—	
	Normal to plane of fire.	In plane of fire.
	Per cent.	*Per cent.*
7,800	17.5	71.8
6,800	21	86.9
3,550	33.5	98

It was after having been present at the fire of this howitzer at Meppen, in August, 1879, that a commission from our navy reported:

"From all this we think it may be concluded, if the probable errors which may be met are considered, that the probability of striking the deck of a vessel with curved fire is, notwithstanding the great accuracy obtained, pretty limited for large distances and rather large for distances between 2,000 and 3,000 meters.

"Remembering that many guns may at once be fired against a vessel, and considering the effect that a single heavy projectile may produce in the vital part of a vessel by striking its deck, we can but feel the necessity of opposing an efficient resistance against curved fires, which are, without doubt, sufficiently serious to a fleet that desires to act against a coast."

It remains to consider the probability of hitting with curved fire a vessel which moves in any direction with a given velocity I do not think that in a real attack against a fixed object in which many vessels take part they can maneuver with a velocity approaching that of their ordinary movement; they are prevented in their evolutions in the midst of smoke and in a relatively small area by the wish to maintain their proper distance of fire; and to prevent collisions, an occurrence that is more probable the greater the number of types of vessels, the nearer the shore, and the greater the difference of their radii of evolution is. Yet it is necessary to admit as possible that a squadron may carry on a bombardment keeping up a velocity of about six miles, and this velocity, by which a vessel displaces itself during the time necessary to aim in fire at will, combined with the subsequent displacement during the time of flight of the projectile, has an injurious effect on the probability of hitting.

It is true that up to a certain point the injurious effect of the vessel's motion during the flight of the projectile may be diminished by aiming in front of the moving vessel, but in practice it will be very difficult for the gunner to tell quickly how much in advance he should aim, and it will afterward be equally difficult to aim at a point of the path through which the vessel should pass, but which it has not yet reached. To compute the probability of striking the deck of a vessel that moves with the velocity of six miles is a difficult problem, and Commandant De Luca, in his work already several times quoted, has solved it admirably. He supposed a vessel of the dimensions already given, deduced a formula appropriate to the case, and translated it into figures for the French rifled howitzer of 22 c. m., which is supposed to fire with a fixed angle of 40° elevation at distances of 2,000, 3,000, and 4,000 meters.

We condense the calculations and conclusions of this eminent officer:

RIFLED HOWITZER OF 22 C. M. (FRENCH).

Distance in meters.	Mean deviation in meters.		Time of flight, in seconds.
	Longitudinal.	Lateral.	
2,000	43	5	18
3,000	55	7	22
4,000	65	10	25

Admitting that the time necessary for aiming is 30 seconds and calling—

P_1 the probability in per cent. of hitting without taking into account the influence of time of flight, that is, supposing it possible to correct for it in aiming;

P_2 the probability of hitting supposing no such precautions to be taken for the time of flight;

P_3 the probability of hitting on the supposition that in aiming the lateral displacement of the vessel during the time of flight is taken account of;

θ the angle between the vessel and the plane of fire, there results:

θ in degrees.	2,000 meters.			3,000 meters.			4,000 meters.		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
0	15.41	2.48	2.48	14.32	2.96	2.96	11.08	2.85	2.85
45	9	0.11	2.91	9.24	0.04	3.72	8.72	0.08	4.10
90	13.30	0.07	13.30	10.35	0.00	10.35	8.77	0.01	8.77

Since the vessel may move indifferently in any direction whatever, and θ therefore may have any value, the absolute probability, independent of θ, will be the mean of all possible ordinates of the corresponding curve; that is, the height of the rectangle of area equal to that comprised in the curve. From this the commandant derives for the French 22 c. m. howitzer the following table of the probability of hitting in per cent.:

	2,000 meters.	3,000 meters.	4,000 meters.
In the hypothesis P_1	11.2	9.6	9.2
In the hypothesis P_2	0.7	0.5	0.5
In the hypothesis P_3	5.6	5.2	5.1

And the final conclusions of this eminent officer are as follows:

"Examining these figures, remembering the hypotheses from which they were derived, considering the short time allowed for aiming, the difficulty of estimating by the eye the velocity of the vessel in order to correct for the time of flight, and the impossibility of drilling at fire against a vessel in motion, it does not seem to us at all exaggerated if we admit that in curved fire against a vessel in motion the probability of hitting does not exceed 2 or 3 per cent."

Accepting as the author has presented them the formulæ for computing the values of P_1, P_2, P_3, I thought it well to apply them to the direct fire of our 24 c. m.

gun at three distances, for which the time of flight is sensibly equal to that of the 22 c. m. French howitzer at 2,000, 3,000, and 4,000 meters.

As will be seen, I consider as to its effects the fire of this gun at 6,000 meters and beyond as a true curved fire. The data for direct shell fire from this gun, of long type, are:

Distance in meters.	Mean deviation in meters.		Time of flight, in seconds.
	Longitudinal.	Lateral.	
5,800	91.26	8.78	18
6,800	106.47	11.49	21.9
7,500	118.30	13.85	24.9

On these data were computed the values referred to above, giving the following results:

θ in degrees.	5,800 meters.			6,800 meters.			7,500 meters.		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
0	13.37	0.70	0.70	15.26	0.84	0.84	15.44	0.75	0.75
45	6.75	0.00	1.00	8.15	0.00	1.5	9.0	0.00	1.5
90	17.5	0.00	17.5	15.5	0.00	15.5	14.0	0.00	14.0

And the values of the absolute probability independent of θ and relative to P_1 and P_3 result, in per cent.:

	5,800 meters.	6,800 meters.	7,500 meters.
In the hypothesis P_1......	11.09	11.77	11.86
In the hypothesis P_3......	5.05	4.84	4.81

The absolute probability relative to P_2 has not been calculated, but it is certain that it has values less than that found for the French 22 c. m. howitzer.

Comparing this table for the rifle of 24 c. m., firing at great distances, with that calculated by Commandant De Luca for the howitzer of 22 c. m., firing at mean distances, it is plain that they are nearly equivalent, and hence it does not seem difficult to extend the conclusion of the commandant to the whole depth of the zone which the table of fire of the long 24 c. m. rifle gives us the possibility of reaching.

In other words, it seems we can admit that the probability of hitting with shell curved fire from the 24 c. m. rifle up to 9,000 meters will not be less than 2 or 3 per cent. when we take for a target the deck of a vessel moving with a velocity of 6 miles per hour.

These results, which at first view seem poor, do not seem so to me when we consider the condition in which a squadron is relative to a coast battery while at such a distance away that it cannot harm it, and consider the immensely destructive effects that a successful shot from the shore may produce on the vessel struck. The experiments on the Guerriera mentioned by the Admiral St. Bon make it probable that two large projectiles which burst after penetrating an armored deck would be sufficient to

make the vessel withdraw from action; and the withdrawal by one vessel of the squadron and the incessant rain of heavy projectiles against the one or more still remaining seem sufficient to demoralize the crews. As in a battle on land a tactical unit is considered disorganized when it has lost from one-third to one-fourth of its strength, so I believe that an attacking squadron would cease bombarding if two or three of its vessels were forced to retire by the curved fire of sea-coast artillery.

ons and Tactics of Siege-operations of the